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Physiological potential of soybean seeds subjected to industrial treatment and storage time

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Abstract

The use of treated seeds is a common practice among soybean producers, as it provides protection against pests and diseases existing in the soil, preventing their spread in exempt areas. Therefore, chemical treatment combined with different products becomes essential to guarantee success in the field.The objective of this study was to assess the influence that 7 industrial seed treatments (ISTs) and their respective slurry volumes have on the physiological potential of soybean seeds. The assay was carried out in a completely randomized design with 4 replications, with the treatments being arranged in a 7x6 factorial scheme (industrial treatments x storage periods). The chemical treatments were: control (untreated seeds) (ST1), fungicide + insecticide-1 + drying powder (ST2), fungicide + insecticide-1 + drying powder + micronutrient (ST3), fungicide + insecticide-1 + drying powder + micronutrient + biostimulant (ST4), fungicide + insecticide-1 + polymer + drying powder + insecticide-2 (ST5), fungicide + insecticide-1 + polymer + drying powder + insecticide-2 + micronutrient (ST6), fungicide + insecticide-1 + polymer + drying powder + insecticide-2 + micronutrient + biostimulant (ST7). For each IST, the specific slurry volume was 0, 350, 550, 1050, 500, 700 and 1200 mL 100 kg-1 of seeds, respectively. The seeds were stored for periods of 0, 15, 30, 45, 60 and 90 days and subsequently checked for their physiological potential. In each storage period, the following tests were conducted: germination, first count, accelerated aging, emergence speed index, and final emergence in sand substrate. Among the evaluated treatments, ST4 and ST7 were the most harmful to the physiological quality of the seeds in all storage periods, since they presented the greatest slurry volume. In relation to treatments with less harmful effects on seeds, treatments ST2 and ST3 presented higher averages for most of the variables analyzed.

Keywords: Agrochemicals; Deterioration; *Glycine max* (L) Merr.; Storage periods; Vigor.
Abbreviations: IST_industrial seed treatment; SP_storage period; SGT_standard germination test; FC_first count; ESI_ emergence speed index; FE_ final emergence in sand substrate; AA_ accelerated aging; DF_ degrees of freedom; CV_coefficient of variation; ST1_treatment 1; ST2_treatment 2; ST3_treatment 3; ST4_treatment 4; ST5_treatment 5; ST6_treatment 6; ST7_treatment 7; MAPA_Brazilian Ministry of Agriculture, Livestock and Supply.

Introduction

Seed treatment has become a common practice among soybean producers (Marcos Filho, 2015), in this perspective, research has indicated that treated and stored seeds may cause loss of vigor and reduction in germination (Camargo et al., 2022). In this perspective, active ingredients from the neonicotinoid group such as imidacloprid, thiamethoxam and clothianidin were banned in Europe, indicating the need to restore their effects in other countries (Vojvodić and Bažok, 2021). The incorporation of fungicides, insecticides and biostimulants have made IST an essential practice to obtain high productivity, but studies with soybean seeds have found that certain chemicals applied via seeds are capable of reducing the germination potential, as well as seedling emergence, and vigor (Moraes Dan et al., 2012).

According to Deuner et al. (2014), Bittencourt et al., (2000) and Fessel et al., (2003), the effect of phytotoxicity is directly related to the product used, and can be intensified by the dose applied and by how long the seeds remain stored. However, it is important to emphasize that industrial seed treatment (IST) can bring about several benefits, such as greater precision as to slurry volume, more homogeneous coating, adequate dose, and more uniform seed quality, in addition to being a technology transfer vehicle (Santos et al., 2018). The practice of sowing hardly occurs in suitable field conditions, or in areas free of pests and pathogens; in these circumstances, seed treatment becomes indispensable, since it is capable of mitigating the occurrence of pests at the

beginning of the cycle and, consequently, reduces the risk in intact areas, respectively (Balardin et al., 2011).
For a lower number of products applied in pre-sowing, IST combines agrochemicals, mineral nutrients, and nitrogen-fixing microorganisms in a single formulation, with application via seeds (Menten and Moraes, 2010). From this perspective, research has indicated that an increase in chemical products in seed treatment favors a loss of vigor, culminating in low emergence in the field (Pereira et al., 2020).
The hypothesis established in the present study is that different chemicals associated with a high volume of slurry promote negative effects on seed quality, especially during storage. In light of the foregoing, the objective of this study was to evaluate the physiological quality of soybean seeds subjected to industrial treatments as a function of different storage periods.

Results and discussion

Initially, the assumptions of normality and homogeneity of variances were accepted through the Shapiro-Wilk and Bartlett tests (p-value > 0.05). Table 1 shows the results for the analysis of variance F test; significance (p-value < 0.05) was found for both the main effects and the double interaction between storage period and seed treatment

Effect of chemical treatment on the physiological quality of seeds and formation of normal seedlings
With regard to the SGT, comparing the seed treatments and considering each of the storage periods, Table 2 shows, broadly speaking, that there are significant differences between treatments, with ST4 and ST7 presenting, in most periods, the lowest means for the observed variable.
The results of this research indicate that, regardless of the agrochemicals used in the treatments, the lowest means were those that presented the greatest slurry volume. Similar results were found by Brzezinski et al. (2017) and Abati et al. (2020); for these authors, the physiological potential and germination of seeds is largely affected by slurry volume, especially under inadequate storage conditions. As for the comparison between storage periods, and considering the seed treatments, significant differences were observed, and it is worth noting that the mean of the variable under analysis decreases as the storage period increases.
With regard to the results referring to the FC variable (Table 3), comparing the seed treatments, in each of the storage periods, it is observed, in general, that there are significant differences between the treatments, and that ST4 provided, in most periods, the lowest means for the variable under analysis.
After 60 days of storage, most treatments, except ST1 (control) and ST2, showed compromised germination potential for selling, considering that the mean values of normal seedlings in the germination test were below 80%, a value which was established by the Brazilian Ministry of Agriculture, Livestock and Supply (MAPA) as the minimum to guarantee the distribution of soybean seeds in Brazil, showing that, after this period, the quality of the seeds is slightly affected. Therefore, in these circumstances, it is recommended that the industrial treatment be applied in advance, in order to minimize possible deleterious effects (Zambom, 2013; Strieder et al., 2014).
Moreover, it is essential to highlight that the presence of biostimulant in treatments ST4 and ST7 did not have a positive impact, mainly due to the slurry volume in these treatments being higher than in the others. In this sense, Moterle et al. (2011) suggest that the absorption of phytohormones in seeds is lower compared to foliar application via plants; such a fact can be explained by the greater sensitivity of tissues depending on the development stage of the plants and the cumulative effect of phytohormones, in addition to the greater contact surface.
Concerning the comparison between storage periods, and considering the seed treatments, the same behavior observed in the germination test was noticed, confirming that, the longer the storage period, the lower the resulting means.
For the ESI variable (Table 4), the results showed significant differences between treatments, with ST7 presenting, in most periods, means lower than the others. Such findings come from the range of products included in the seed treatment, since slurry volume directly affects the emergence of seedlings in the field.
According to studies, a high number of products added to slurry are responsible for deleterious effects on seed quality and seedling emergence (Pereira et al., 2021, Suzukawa et al., 2019). In this scenario, Taylor and Salanenka (2012), when studying coating in seeds treated with fungicides and insecticides alone or associated with polymers, found that the rate of imbibition, regardless of the products used, is maintained. Therefore, slurry volume can be considered a decisive factor for the loss of the physiological potential of the seeds. With respect to the comparison between storage periods, and considering the seed treatments, significant differences and a behavior similar to that from the previous analysis are verified.
For the FE in sand substrate variable (Table 5), significant differences can be observed between treatments, with ST7 providing, in most periods, the lowest means for the variable under analysis. According to Pereira et al. (2020), the storage period can be considered a limiting factor capable of promoting deterioration and loss of physiological quality and vigor, as performance is compromised, especially in treated seeds.
With regard to the comparison between storage periods, and considering the seed treatments, significant differences are observed. It is possible to notice that, after 45 days of storage, all treatments showed a significant decrease, with the exception of ST3 and ST4, which maintained satisfactory levels of emergence (above 79%).
From the results contained in Table 6, referring to the AA variable, it is inferred, in general, that there are significant differences between the treatments, with ST4 presenting the lowest means for the variable under analysis, for most of the storage periods.
In this regard, Vieira et al. (2002) and Bewley and Black (1994) observed that, in low vigor seeds, imbibition becomes more pronounced, especially when they are subjected to high slurry volumes, given that more vigorous seeds have the ability to withstand greater physiological disturbances by reorganizing cells and maintaining the integrity of the plasmatic membrane. However, in lower-quality seeds, this behavior is compromised by the permeability of the membranes, which, consequently, absorb water more quickly.
As for the storage periods, considering the seed treatments, significant differences were found, since the longer the storage period, the lower the means of the variable under analysis.

Material and methods

Quality assessment of soybean seeds after different storage periods
The experiment was carried out at the Seed Technology Laboratory of the Agriculture-Applied Research Center, belonging to the Agrarian Sciences Center of the State University of Maringá (UEM).

Table 1. Analysis of variance for the following variables: Standard Germination Test (SGT), First Count (FC), Emergence Speed Index (ESI), Final Emergence in sand substrate (FE), and Accelerated Aging (AA).

Sources of Variation	DF	Mean Squares				
		SGT (%)	FC	ESI	FE (%)	AA (%)
SP	5	6357***	8039***	289.09***	25229***	13472***
IST	6	1662***	3114***	8.09***	1353***	2523***
SP x IST	30	51***	282***	4.83***	350***	121***
Residuals	126	12	18	0.38	48	24
CV (%)	-	8.72	5.57	9.67	10.03	17.00
Total Mean	-	40.50	76.63	6.38	69.38	28.48

*** Considered significant if p-value < 0.05 by F-test; SP: storage period; IST: industrial seed treatment; DF: degrees of freedom, and CV: coefficient of variation (%).

Table 2. Standard Germination Test (SGT) of soybean seeds as a function of Seed Treatment and Storage Periods.

Seed Treatments*	Storage Periods (days)					
	0	15	30	45	60	90
ST1	76.50 aA	66.50 aB	56.50 aC	51.00 aC	41.00 aD	33.00 aD
ST2	62.50 bA	54.00 bB	50.50 abBC	45.00 bCD	41.00 aD	31.00 aE
ST3	59.50 bA	50.50 bcB	45.50 bcBC	38.50 cCD	32.00 bD	17.50 bcE
ST4	52.00 bA	44.50 bcdB	38.00 dC	31.50 dD	12.00 cE	5.50 dF
ST5	61.00 bA	50.00 bcdB	42.00 cdBC	38.00 cCD	32.50 bDE	25.00 abE
ST6	56.00 bA	47.50 cdB	43.00 cdBC	38.00 cC	31.00 bD	11.50 cdE
ST7	56.00 bA	42.50 dB	37.50 dBC	32.00 dC	16.50 cD	5.50 dE

* Means followed by distinct lowercase letters in the columns and uppercase letters in the rows (p-value < 0.05) differ from each other by Tukey's test.

Table 3. First Count (FC) in the soybean seed germination test as a function of Seed Treatment and Storage Periods.

Seed Treatments*	Storage Periods (days)					
	0	15	30	45	60	90
ST1	100.00 aA	98.00 aAB	93.00 aBC	89.50 aCD	86.50 aD	78.50 aE
ST2	99.50 aA	93.00 abB	86.50 bC	84.00 abCD	81.50 abD	75.00 abE
ST3	99.00 aA	88.50 bB	85.00 bB	81.50 bcB	68.00 bcC	61.50 bcC
ST4	96.00 aA	79.00 cB	68.00 dC	60.00 eC	37.00 dD	23.00 eE
ST5	98.00 aA	91.50 bAB	83.50 bcBC	78.50 bcC	73.50 abcC	57.50 cD
ST6	99.50 aA	87.50 bAB	80.00 cBC	74.00 cdCD	62.50 cD	41.50 dE
ST7	98.00 aA	79.00 cB	72.50 dB	67.50 deB	42.00 dC	20.50 eD

*Means followed by distinct lowercase letters in the columns and uppercase letters in the rows (p-value < 0.05) differ from each other by Tukey's test.

Table 4. Emergence Speed Index (ESI) of soybean seeds as a function of Seed Treatment and Storage Periods.

Seed Treatments*	Storage Periods (days)					
	0	15	30	45	60	90
ST1	10.35 aA	8.83 abB	6.48 cdC	5.15 bD	3.83 bcE	2.35 bcF
ST2	11.10 aA	9.58 aA	5.90 dB	4.67 bBC	3.15 bcC	1.28 cdD
ST3	9.80 aA	8.58 abB	7.40 bcC	6.85 aCD	6.33 aDE	5.55 aE
ST4	10.88 aA	9.30 abAB	8.78 aB	7.23 aB	2.90 bcC	0.15 dD
ST5	10.65 aA	9.28 abB	8.20 abB	6.93 aC	4.35 bD	0.40 dE
ST6	9.98 aA	8.95 abAB	7.80 abcB	5.03 bC	4.18 bC	2.65 bD
ST7	10.75 aA	8.18 bB	7.08 bcdC	4.45 bD	2.43 cE	0.68 dF

*Means followed by distinct lowercase letters in the columns and uppercase letters in the rows (p-value < 0.05) differ from each other by Tukey's test.

Table 5. Final Emergence (FE) of soybean seeds in sand substrate as a function of Seed Treatment and Storage Periods.

Seed Treatments*	Storage Periods (days)					
	0	15	30	45	60	90
ST1	100.00 aA	93.00 abAB	82.00 bB	59.00 bC	41.00 bD	23.25 bcE
ST2	100.00 aA	93.00 abAB	83.00 abB	62.00 abC	36.00 bD	17.00 bcdE
ST3	100.00 aA	98.00 aA	93.00 aA	81.00 aB	75.00 aB	60.00 aC
ST4	100.00 aA	97.00 abA	89.00 abA	82.00 aA	36.00 bB	2.00 dC
ST5	96.00 bA	93.00 abA	88.00 abAB	79.00 abB	53.00 abC	6.00 dD
ST6	97.00 bA	93.00 abA	85.00 abA	69.00 abB	55.00 abB	33.00 bC
ST7	95.00 bA	90.00 bA	80.00 bA	59.00 bB	32.00 bC	9.00 cdD

*Means followed by distinct lowercase letters in the columns and uppercase letters in the rows (p-value < 0.05) differ from each other by Tukey's test.

Table 6. Accelerated Aging (AE) of soybean seeds as a function of Seed Treatment and Seed Storage Periods.

Seed Treatments*	Storage Periods (days)					
	0	15	30	45	60	90
ST1	70.50 aA	54.00 aB	45.00 aC	35.00 aD	26.00 aE	4.00 bF
ST2	77.00 aA	56.50 aB	34.00 bC	26.00 abCD	17.00 bD	11.00 aD
ST3	61.50 bA	48.00 abB	29.50 bC	19.00 bcCD	10.50 bcDE	2.50 bE
ST4	36.00 cA	21.50 cB	9.50 cC	3.00 dCD	1.00 dCD	0.00 bD
ST5	66.50 abA	54.00 aB	42.00 aC	32.50 aC	14.00 bD	5.50 abD
ST6	59.50 bA	43.50 abB	31.00 bC	16.50 bcD	5.50 cdE	1.00 bE
ST7	59.50 bA	35.00 bcB	14.00 cC	9.00 cdCD	0.50 dD	0.00 bD

*Means followed by distinct lowercase letters in the columns and uppercase letters in the rows (p-value < 0.05) differ from each other by Tukey's test.

To set out the tests, 2.5 kg of non-conventional seeds, with transgenic technology, were used. As for seed treatment, it was conducted in an industrial unit. A continuous seed coating device was used; the seeds were subsequently allocated in kraft paper bags and kept under laboratory ambient conditions, simulating conventional storage. The trial was conducted by means of a completely randomized experimental design in a factorial scheme (7 industrial treatments x 6 storage periods), with 4 replications, totaling 42 treatments.

The treatments were defined as follows: control (untreated seeds) (ST1), [1]fungicide + [2]insecticide + [3]drying powder (ST2), [1]fungicide + [2]insecticide + [3]drying powder + [4]micronutrient (ST3), [1]fungicide + [2]insecticide-1 + [3]drying powder + [4]micronutrient + [5]biostimulant (ST4), [1]fungicide + [2]insecticide + [6]polymer + [3]drying powder + [7]insecticide (ST5), [1]fungicide + [2]insecticide-1 + [6]polymer + [3]drying powder + [7]insecticide + [4]micronutrient (ST6), [1]fungicide + [2]insecticide + [6]polymer + [3]drying powder + [7]insecticide + [4]micronutrient + [5]biostimulant (ST7) (Supplementary Table 1). For each IST (Industrial seed treatment), the specific slurry volume was 0, 350, 550, 1050, 500, 700 and 1200 mL 100 kg-1 of seeds, respectively. The drying powder was added to the slurry volume; it is a product that dries quickly and does not affect the volume of the mixture.

The evaluations were carried out after 0, 15, 30, 45, 60 and 90 days after application, and the physiological potential of the seeds was determined for each of the storage periods. After the seeds were treated, their physiological quality was evaluated using the following tests: germination test (Brasil, 2009), first germination count (Brasil, 2009), accelerated aging test (Marcos Filho, 1999), emergence speed index (Maguire, 1962), and final emergence in sand substrate (Nakagawa, 1999).

Statistical analysis

Data were analyzed on the R software, version 4.0.2 (R Core Team, 2020). The hypothesis of normality and homogeneity of variances for the variables was verified using the Shapiro-Wilk and Bartlett tests, respectively. The analysis of variance F test was applied to identify differences between treatments and storage period. With significance in the analysis of variance F test being found, Tukey's test was used to compare the means of the treatments. In all tests, a significance level of 5% ($p < 0.05$) was considered.

Conclusion

The physiological quality and vigor of the seeds decrease as the storage period increases, since, regardless of the agrochemicals used, the slurry volumes corresponding to the ST4 and ST7 treatments were considered the most harmful to most of the analyzed variables. In relation to treatments with less harmful effects on seeds, treatments ST2 and ST3 presented higher averages for most of the variables analyzed.

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References

Abati J, Brzezinski CR, Bertuzzi EC, Henning, FA, Zucareli C (2020) Physiological response of soybean seeds to spray volumes of industrial chemical treatment and storage in different environments. Journal of Seed Science: 42.

Balardin RS, Silva FDLD, Debona D, Dalla Corte G, Dalla Favera D, Tormen N R (2011) Tratamento de sementes com fungicidas e inseticidas como redutores dos efeitos do estresse hídrico em plantas de soja. Ciência Rural. 41: 1120-1126.

Bewley JD, Black M (1994). Cellular events during germination and seedling growth. In Seeds. Springer, Boston, MA.

Bittencourt SRM, Fernandes MA, Ribeiro MC, Vieira ERD (2000) Desempenho de Sementes de milho tratadas com inseticidas sistêmicos. Revista Brasileira de Sementes. 22: 86-93.

Bittencourt SRM, Fernandes MA, Ribeiro MC, Vieira ERD (2000) Desempenho de Sementes de milho tratadas com inseticidas sistêmicos. Revista Brasileira de Sementes. 22: 86-93.

Brasil. Ministry of Agriculture, Livestock and Supply (2009) Rules for Seed Analysis. Ministério da Agricultura, Pecuária e Abastecimento. Secretariat of Agricultural Defense. Brasília: MAPA/ACS, 395 p.

Brzezinski CR, Abati J, Henning FA, Henning AA, França JDB, Krzyzanowski FC, Zucareli C (2017) Spray volumes in the industrial treatment on the physiological quality of soybean seeds with different levels of vigor. Journal of Seed Science. 39: 174-181.

Camargo FRT, Teixeira IR, Silva IL, Sousa WS, De Araújo MEV, Corrêa PC (2022) Viability and vigor of soybean seeds as a result of industrial seed treatment and stored in different environments. Semina: Ciências Agrárias. 43: 2607-2628.

Dan, LGDM, DAN, HDA, Piccinin, GG, Ricci, TT, Ortiz AHT (2012) Tratamento de sementes com inseticida e a qualidade fisiológica de sementes de soja. Revista Caatinga. 25, 45-51.

Deuner C, Rosa KC, Meneghello GE, Borges CT, Almeida ADS, Bohn A (2014) Physiological performance during storage of corn seed treated with insecticides and fungicide. Journal of Seed Science. 36: 204-212.

Fessel SA, Mendonça EAFD, Carvalho RVD, Vieira RD (2003) Efeito do tratamento químico sobre a conservação de sementes de milho durante o armazenamento. Revista Brasileira de Sementes. 25: 25-28.

Maguire JD (1962) Speed of germination in selection and evaluation for seedling emergence and vigor. Crop Science. 2: 176-177.

Marcos Filho J (1999) Testes de vigor: importância e utilização. Vigor de sementes: conceitos e testes. Londrina: ABRATES, 1: 1-21.

Marcos Filho, J. (2015). Fisiologia de sementes de plantas cultivadas: Fealq. FEALQ,

Menten JO, Moraes, MHD. (2010). Tratamento de sementes: histórico, tipos, características e benefícios. Informativo Abrates. 20: 52-71.

Moterle LM, Santos RFD, Scapim, CA, Braccini, ADL, Bonato CM, Conrado T (2011) Efeito de biorregulador na germinação e no vigor de sementes de soja. Revista Ceres. 58: 651-660.

Nakagawa J (1999) Testes de vigor baseados no desempenho das plântulas. Vigor de sementes: conceitos e testes. Londrina: ABRATES. 1: 1-24.

Pereira RC, Pelloso MF, Correia LV, Matera TC, Dos Santos RF, Braccini AL, De Bastiani GG, Coppo C, Da Silva BG (2020) Physiological quality of soybean seeds treated with imidacloprid before and after storage. Plant, Soil and Environment. 66: 513-518.

Pereira RC, Pereira LC, Braccini AL, Correia, LV, Pelloso MF, Matera TC... Dos Santos RF (2021) Physiological quality of soybean seeds stored after industrial treatments with different chemicals. Research, Society and Development. Piracicaba, Brazil.

R Core Team. (2020). R: a language and environment for statistical computing. Vienna, AT: R Foundation for Statistical Computing.

Santos SFD, Carvalho ER, Rocha DK, Nascimento RM (2018) Composition and volumes of slurry in soybean seeds treatment in the industry and physiological quality during storage. Journal of Seed Science. 40: 67-74.

Strieder G, Foguesatto RJ, Gadotti GI, Luz MLGS, Luz CD, Gomes MC, Scherer VS (2014) Estudo técnico e de cenários econômicos para implantação de uma unidade de tratamento industrial de sementes de soja e trigo. Informativo Abrates. 24: 118-123.

Suzukawa AK, Mariucci GE, Pereira LC, Braccini AL, Ponce RM, Marteli DC, Lima LHS, Angelotti P, Silva VFV (2019) Slurry composition and physiological quality of treated soybean seeds over storage. Journal of Agricultural Science. 11:376-381.

Taylor AG, Salanenka YA (2012) Seed treatments: phytotoxicity amelioration and tracer uptake. Seed Science Research. 22: 86-90.

Vieira RD, Penariol AL, Perecin D, Panobianco M (2002) Condutividade elétrica e teor de água inicial das sementes de soja. Pesquisa agropecuária brasileira, 37: 1333-1338.

Vojvodić M, Bažok R. Futuro do tratamento de sementes com inseticidas. Sustentabilidade. 13: 8792, 2021.